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Development of a Block Scheme of Optoelectronic Device for Control of Gas Concentration

Sultonov Shukhrat Davlyatovich
Associate Professor, Fergana Polytechnic Institute
Fergana, Uzbekistan
abrortak78@mail.ru

Abstract: This article presents and describes the principle of operation of an optoelectronic device for monitoring the concentration of gases in biogas and geothermal combined plants based on a block diagram and timing diagrams.

Key words: optoelectronics, semiconductor, radiation source, block diagram, timing diagrams, concentration.

The rapid development of optoelectronics and its elemental base, the creation of new highly efficient semiconductor radiation sources in the near-IR region of the spectrum create prerequisites for the development of highly sensitive and accurate, reliable devices for monitoring the concentration of gaseous substances.

On the other hand, optoelectronics, as one of the areas of microelectronics, is developing rapidly. High-performance LEDs for the mid-IR range operating at room temperature, based on quaternary solid solutions of A3B5 compounds, are promising for gas analysis.

In the range of 1.7-4.8 μm, there are intense absorption lines of moisture and such important industrial and harmful gases as methane, CO2, CO, SO_2, H_2S, etc. The LEDs of this series are promising for creating portable gas analyzers, with low power consumption and sufficient high sensitivity and selectivity, even without the use of additional filters and mechanical modulators.

The main advantages of an optoelectronic two-wave device compared to single-wave devices are the high accuracy of control due to the exclusion of non-informative parameters, such as air dustiness, humidity, and the content of aerosol particles on the control result [1].

The block diagram of an optoelectronic two-wave device for monitoring the concentration of hydrocarbons in the air is shown in fig.1, and in fig.2. its timing diagrams are shown.

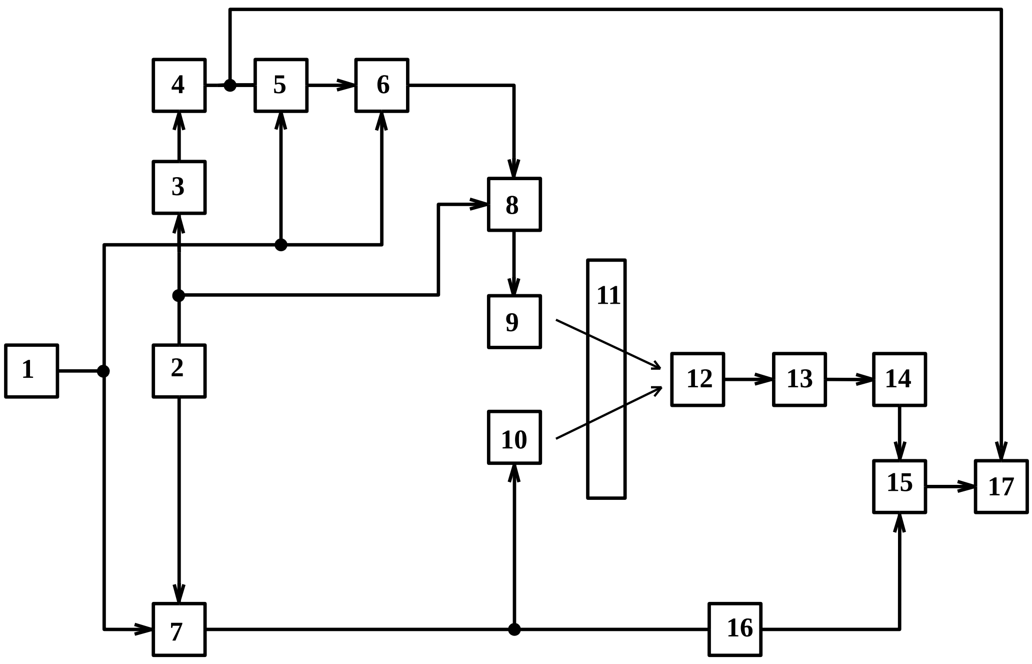

Fig.1. Block diagram of an optoelectronic device for monitoring hydrocarbon concentration in air

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The device for monitoring the concentration of hydrocarbons in the air contains a power source 1, a rectangular pulse generator with two antiphase outputs 2, to one output of which a frequency divider 3 (serial counter) is connected, the output of which is connected via a single-vibrator 4 to the control input of the exponent modulator 5, an emitter repeater 6, two electronic keys 7 and 8, emitting diodes the working 9 and the reference 10, emitting at the reference and working wavelengths, respectively, a gas chamber 11, a photodetector 12 connected to the first differentiating device 13, the output of which is through the threshold input of the coincidence circuit 15, the first input of which is connected to the output of the second differentiating device 16, the input of which is connected to the emitting diode 10, the counter 17, the counting input of which is connected to the output of the coincidence circuit 15, and its “zero setting” input is connected to the output of the single-vibrator 4. The gas chamber 11 is irradiated with two streams radiation $\Phi_{0\lambda1}$ and $\Phi_{0\lambda2}$ at the reference λ_1 and working λ_2 wavelengths, respectively. The radiation fluxes passing through the gas chamber will be equal, respectively:

$$\begin{aligned} \Phi_{\lambda 1} &= \Phi_{0\lambda 1} e^{-kLN_1} \\ \Phi_{\lambda 2} &= \Phi_{0\lambda 2} e^{-kLN_1} \cdot e^{-k_2 LN_2} \end{aligned} \qquad (1)$$

here: $\Phi_{0\lambda1}$ и $\Phi_{0\lambda1}$ – radiation fluxes supplying the gas chamber at wavelengths λ_1 and λ_2, respectively, $\Phi_{\lambda1}$, $\Phi_{\lambda2}$ - radiation fluxes after passing through after passing through the gas chamber at wavelengths λ_1 and λ_2, respectively,
N_1 - concentration of a mixture of gaseous substances,
L - is the length of the optical path, i.e. gas chamber length
N2 - concentration of the determined gaseous substance,
K1 - scattering coefficient of a mixture of gaseous substances,
K2 - absorption coefficient of the determined gaseous substances.Поток $\Phi_{0\lambda1}$ изменяется во времени (t) по экспоненциальному закону:

$$\Phi_{\lambda 1} = Ae^{-\frac{t}{\tau}} \cdot e^{-k_1 LN_1} \qquad (2)$$

here: A – a constant coefficient corresponding to the initial value of the amplitude of the exponential pulse. At the moment of equality of flows $\Phi_{\lambda1}$ and $\Phi_{\lambda2}$

$$\Phi_{0\lambda_2} e^{-k_2 LN_2} = Ae^{-\frac{t_c}{\tau}} \qquad (3)$$

$$N_2 = \frac{1}{K_2 L_\lambda} \cdot t_c \qquad (4)$$

here: t_c – time corresponding to the moment of comparison,
τ - exponent time constant.

The generator 2 of rectangular pulses generates pulses with the required repetition rate. These pulses from antiphase outputs are fed to the input of the frequency divider 3 and to the control inputs of the keys 7 and 8. Rectangular pulses from the output of the frequency divider 3 (Fig. 2.a) are fed to the input of one vibrator 4.

Rectangular pulses with the required duration from the output of one exponential vibrator 5, the output of which is connected through an emitter follower 6 to the output of an electronic key 8, where a discrete exponential current pulse is formed, which flows through the radiating diode 9, causes a radiating flux according to the same law. The pulses that fill the exponent in antiphase will switch the electronic key 7. The current pulse flowing through the emitting diode 10 causes a light flux, the amplitude of which is constant. The flows passing through the gas chamber are perceived by the photodetector 12.

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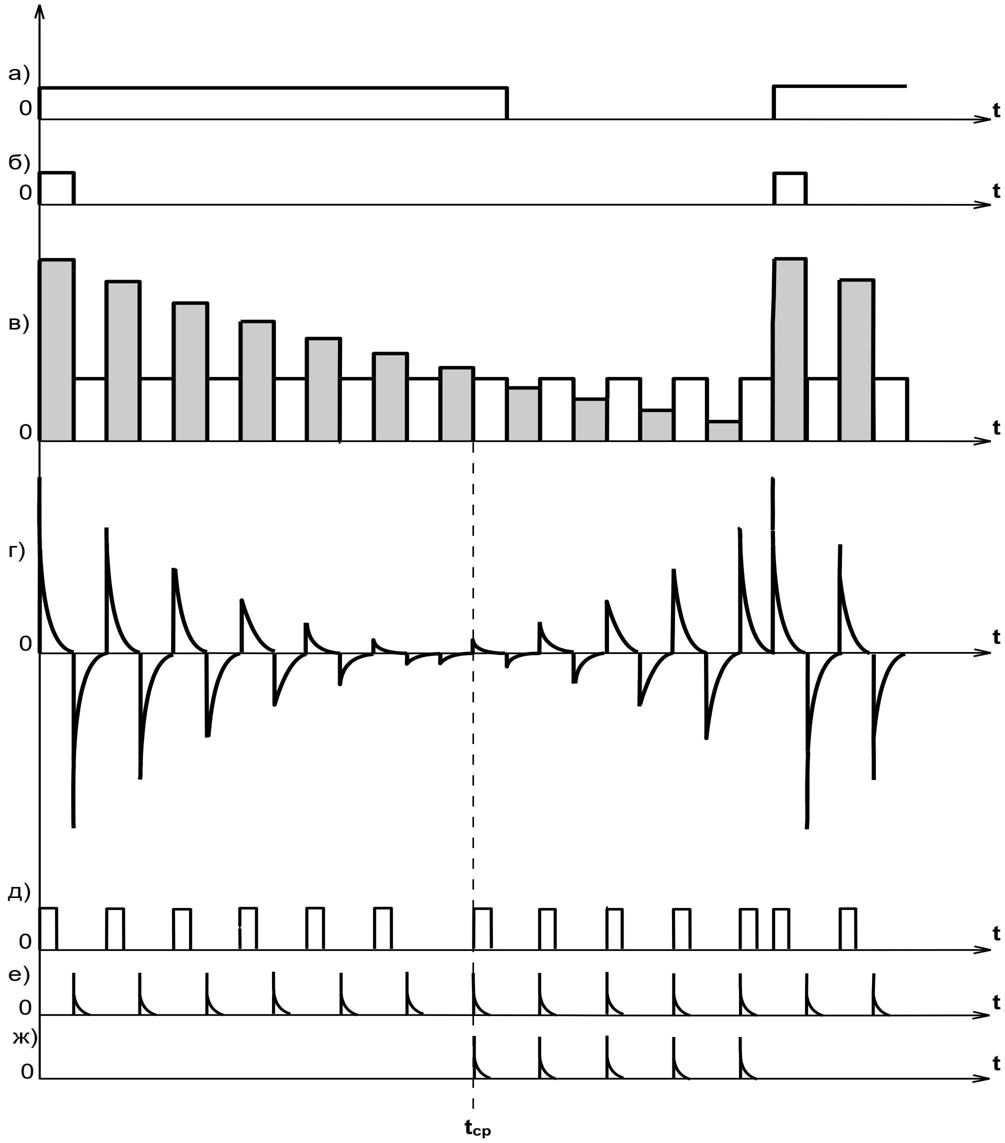

Fig. 2. Timing diagrams explaining the operation of an optoelectronic device for monitoring the concentration of hydrocarbons in the air.

(Fig.2.v) shows the timing diagram of the total photoelectric signal at the output of the photodetector 12. This signal is fed to the input of the first differentiating device 13, from the output of which the differentiated photoelectric signal (Fig.2.g) is fed to the input of the threshold device 14.

Next, the signal from the output of the threshold device 14 (Fig. 2.d) is fed to one of the inputs of the coincidence circuit 15. The signal from the output of the second differentiating device 16 (Fig. 2.e) is fed to the other input of the coincidence circuit 15.

From the moment of comparing tc, a series of pulses appears at the output of the coincidence circuit 15, which are fed to the counting input of the counter 17 (Fig. 2.j).

At the beginning of the next exponential, rectangular pulses are received from the output of one of the vibrator 4 to the “Zero Setting” input of the counter 17, and the counter 17 is prepared. According to the meter readings, the concentration of the gaseous substance to be determined can be determined

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